Early Detection of Diabetic Retinopathy by a Mobile Retinal Photography Service Working in Partnership with Primary Health Care Teams

L.B. Bäcklund*[1], P.V. Algvere[2], U. Rosenqvist[3]

[1]*Department of Ophthalmology, Karolinska Institute, St Erik's Eye Hospital, Stockholm,*
[2]*Department of Ophthalmology, University of Linköping, Linköping, Sweden*
[3]*Department of Public Health and Caring Sciences, University of Uppsala, Uppsala, Sweden*

Community-wide fundus photography was organized for early detection of diabetic retinopathy (DR) by mobile teams. High-quality three-field Kodachrome fundus photography, performed according to the London Protocol through dilated pupils was offered free of charge to primary care; images were taken in the community and assessed centrally. Data are presented from the first 80 primary health care centres (PHCCs) participating, serving 990 000 (about 60 %) of inhabitants in Stockholm County. Beginning in 1990, 6863 diabetes patients were invited by PHCCs; 5490 (80 %) attended. We reached 77 % of persons with known diabetes; only 37 % had had their eyes examined during the preceding 2 years. For 97 % of patients, images were assessable. DR was present in 34 % of patients (non-proliferative DR not requiring further assessment 29 %, non-proliferative DR requiring further assessment 1.1 %, proliferative DR 0.5 % and macular involvement 3.6 %). Re-examination after 2 years was offered to 64 %; follow-up photography after 1 year to 24 %. Fluorescein angiography and/or photocoagulation treatment was performed in 3.6 %. This method of early diagnosis is feasible, acceptable, and reached twice as many patients as did the usual referral-based system of care. We now plan to extend this service to cover the whole county. © 1998 John Wiley & Sons, Ltd.

Diabet. Med. **15 (suppl. 3): S32–S37 (1998)**

Introduction

Early diagnosis of diabetic retinopathy (DR) and timely treatment of sight-threatening diabetic retinopathy (STDR), if available community-wide, should reduce the incidence of blindness due to diabetes.[1,2] Unless STDR is detected in time, adequate laser photocoagulation is delayed and thus ineffective.[3–6] Since DR, even STDR, is often asymptomatic, repeated eye examinations are important.[7] Patient uptake should be maximized.[8] Reduction of a proxy measure for new blindness in diabetes by one-third or more was recently described for Stockholm County,[9] suggesting that one of the main five-year outcome targets of the St Vincent Declaration[1] will be achieved; several possible contributing factors have been described.[9]

People with diabetes, general practitioners (GPs), and other members of diabetes care teams have called for a system for eye examinations that delivers dependable and acceptable examination methods close to where the patient lives or works. Methods should be standardized so that the level of DR is reliably assessed, regardless of when or where examinations are carried out. Progression towards STDR should be monitored and timely treatment guaranteed. Traditionally, diabetes patients have been referred to the nearest ophthalmologist and many causes of referral chain breakdown have been described.[3–6,10] An earlier study in Stockholm County showed eye examination rates to be inadequate despite an education programme.[11]

Aiming to prevent onset and progression of DR and new blindness, the programme described in this paper combined decentralized fundus photography with centralized grading. We attempted to use the information about the earliest manifestations of DR as feedback to

Abbreviations: CI 95% confidence interval, DD disc diameter, DR diabetic retinopathy, ETDRS Early Treatment Diabetic Retinopathy Study, PDR proliferative diabetic retinopathy, PHCC primary health care centre, STDR sight-threatening diabetic retinopathy

Contract grant no. 06615 (The Swedish Medical Research Council)
Sponsors: Stockholm County Council; The Stockholm Diabetes Association; The Swedish Council for Social Research; The Swedish Medical Research Council; The Swedish Society for Medical Science; The Swedish National Board of Health and Welfare; The Karin Sandqvist Foundation; The Elsa and Sigurd Golje Foundation; The Swedish Association of District Medical Officers; The Swedish Diabetes Federation

* Correspondence to: Dr Lars Bäcklund, Fundus Photography Unit, Sabbatsberg Hospital, Box 6401, S-113 82 Stockholm, Sweden.
E-mail: lars.backlund@ood.ki.se

 CCC 0742–3071/98/S30S32–06$17.50

diabetes care teams in order to help patients, nurses, and doctors work together to prevent DR progression. The programme was designed to ensure timely photocoagulation treatment of STDR by reliable early diagnosis and register-based follow-up.

Although retinal photography is often described as 'screening', evidence from high-quality colour fundus photographs is sufficient for a definitive decision, e.g. to change treatments, carry out fluorescein angiography, or, in some cases, perform photocoagulation.[12] We tried to evolve a consistent diagnostic test in order to minimize the need for confirmatory procedures that might alarm patients and cost them time and money. We ensured the availability of resources for evaluation and treatment of abnormalities detected—an important criterion for any early diagnosis programme.[13,14]

Subjects and Methods

Beginning in May 1990, GPs and nurses in primary health care were invited to participate in a fundus photography programme. Invitations were extended through repeated announcements in a newsletter to nurses and doctors in primary care, during training courses, at medical meetings, and in letters to GPs.

Setting

In January 1993, Stockholm County (population 1 678 035) was served by 139 PHCCs; each had a geographically defined catchment area. According to surveys, about 80 % of people diagnosed with Type 2 (non-insulin-dependent) diabetes mellitus were managed by PHCC diabetes teams. During 1994–1995, reorganizations of primary care adversely affected doctor–patient continuity and the referral chain. Cost-cutting has caused a shortage of diabetes nurses, secretaries, and other staff, limiting the time GPs devote to diabetes care.

Subjects

Staff at participating PHCCs were asked to go through their diabetes registers, check patient addresses and phone numbers, ensure that WHO criteria for the diagnosis of diabetes were satisfied,[16] and take responsibility for recruiting and counselling patients. In return, PHCCs received individual DR reports for each participant.

Information on the results of each examination was given to the patient by the doctor responsible for their diabetes care. Patients knew they could contact knowledgeable staff at their PHCC. Examinations were free to PHCCs thanks to County Council funding of the programme. The Regional Ethics Committee of the Karolinska Institute approved the project.

Intervention

Building on experiences from cancer-control programmes,[15] we decided to organize a blindness prevention programme with the following characteristics:

- All adults with known diabetes offered examination.
- Priority for areas known for low incidence of eye examinations.
- Population registers used.
- Examinations performed close to where the patient lives or works.
- Minimal expenses in time, money, and effort for participating patients and diabetes care teams.
- Patients invited by PHCC staff.
- Patients given up-to-date information on DR.
- Patients told who is responsible for the programme.

Two registered ophthalmic nurses visited each participating PHCC. To avoid condensation on lens surfaces, a fundus camera, motorized table, illuminated freestanding visual acuity chart, and other pieces of equipment were sent by heated van the day before the first examination. Twenty to 30 patients a day were examined, using the London Protocol.[2] Patients and staff were informed of diabetes eye care and treatment.

Examinations of each patient in the programme included history, best corrected visual acuity, tropicamide pupil dilatation, and fundus photography followed by Tono-Pen tonometry. A Canon CR4-45 NM non-mydriatic 45° fundus camera was used with Kodachrome 64 Professional colour transparency film.[17] The London Protocol suggested fields covering the macula and areas nasal to the optic nerve head.[2] However, we also included a temporal field and a stereo pair of photographs of the posterior pole (technical details available from authors). Red-reflex photographs were added if monitor picture contrast was low.

Examination results were recorded in writing and subsequently entered into a database management program (FileMaker Pro) which was also used to design forms and reports. PHCCs received confidential data describing their diabetes population. Computer-generated lists were mailed to PHCCs to help ensure attendance rates for re-examination.

Reading Photographs

Fundus photographs were assessed by registered ophthalmic nurses and one GP (L.B.) who had been trained by a retinal specialist (P.A.) until there was complete agreement on the diagnosis of lesions characteristic of moderate to severe non-proliferative DR and of new vessels. Disagreement between graders was resolved by re-evaluation and discussion, with recourse to standard slides.[17] Standard Early Treatment Diabetic Retinopathy Study (ETDRS) criteria for definitions of anatomical landmarks and lesions, e.g. dot haemorrhages ('microaneurysms'), haemorrhages, drusen, hard exu-

dates, micro-infarctions or cotton-wool spots ('soft exudates'), and intraretinal microvascular abnormalities, were adopted.[18] Grading criteria were those of the London Protocol.[2] Further technical details are available from the authors.

Criteria for Referral to Fluorescein Angiography

Patients were referred to angiography if the fundus photographs showed signs of 'sight-threatening diabetic retinopathy, requiring immediate referral' or 'lesions to be referred as soon as possible for assessment by an ophthalmologist', as defined in the field guide-book published for the IDF/WHO Europe Working Group on Blindness as part of the Action Programme for the Implementation of the St Vincent Declaration.[20]

Ensuring Timely Photocoagulation

When fluorescein angiography showed features requiring laser treatment (focal leakage in the macula, macular oedema, severe non-proliferative DR or new vessels), patients were informed by letter or telephone. Since cataract surgery may cause macular oedema, we tried to ensure evaluation by a retinal specialist prior to lens implantation, enabling pre-operative angiography and photocoagulation to be carried out when indicated. Referrals to photocoagulation were entered into a computer register; weekly checks were made until documentation of initiated laser treatment was received and reminders produced and forwarded as necessary. At 3-month intervals, the computer generated reminders to ensure that follow-up visits took place.

Results

In 1990–1993, invitation letters were sent by 80 PHCCs (serving a population of 990 000), and from one hospital department of internal medicine, to 6863 people with diabetes, inviting them to participate in the programme; 80 % (48 % women) attended. Median age of participants was 68 (range 13–93) years. Median duration (time since diagnosis) of diabetes was 6 years (75th percentile 12, range 0–71 years; missing data on 168 patients).

Thirty-three per cent of patients were on diet alone, 47 % on oral hypoglycaemic agents and 19 % on insulin (4 % with tablets). The number of daily doses of insulin was 1 (for 5 % of participants), 2 (9 %), 3 (1 %), and 4 or more (4.4 %).

Frequency of Previous Eye Examinations

Of the patients examined in the first 16 PHCCs, before eye care entered an internal market system, 65 % remembered ever having had their eyes examined through dilated pupils, 43 % within the last 5 years. During the 2 years prior to entering the programme, 36.5 % had been examined; 29.4 % by County Council-employed ophthalmologists, 3.6 % by ophthalmologists in private practice, and 3.5 % by GPs.

Attendance Rates

We offered examinations to all patients with known diabetes, setting no age limits. A total of 1353 patients (77.3 % of those invited) were photographed in the first 16 PHCCs. These PHCCs served catchment areas with a total population of 207 627. At five PHCCs, GPs decided to exclude certain patients above 80 years of age ($n = 21$) known to have opacities of the ocular media.

Participation rate varied widely. Of the first 1353 patients, 10.7 % declined examination or wanted to change their appointment time and 11.3 % did not attend when first invited; PHCC staff were asked to contact non-attenders to offer eye examination to be performed by photography at another PHCC or by an ophthalmologist.

At those PHCCs where the fundus photography activities were presented to and discussed by the entire staff, 80 % participation rates were exceeded. The highest participation rates (90–99 %) were achieved if an initial letter, signed by members of the PHCC diabetes care team, was sent to inform patients of the purpose of eye examinations, giving them a chance to choose a day and express their views by phone or in writing.

Retinopathy Diagnoses

From the first 5490 patients photographed, assessable photographs were obtained for 97.3 %. Some features of DR were found in 34 % of patients (CI 33 to 35 %). The distribution of DR is shown in Table 1. Of patients with new vessels in one or both eyes, 50 % also had hard exudates in the macula of one or two eyes.

Diagnosis of exudative diabetic maculopathy (the most common form of STDR) from colour photographs agreed with findings of macular leakage on fluorescein angiography except in four patients with cataract. Retinal pigment epithelium defects were overdiagnosed as hard exudates for three eyes of two patients. Exudates were not detected in photographs from two patients, both with PDR.

Technical Quality

High-quality images were achieved in 85 % of patients. Cataract caused hazy but assessable photographs in both eyes of 7 % of patients with onset of diabetes after 30. Some photographs of the posterior pole showing haze were easier to evaluate by direct stereo viewing than by projection.

Technical failure rate was 2.8 %. Unacceptable picture quality was due to media opacities in 2 %, miosis in both eyes in 0.4 %, and to a combination of factors (processing errors, flash tube malfunction, refusal to accept mydriatics, miosis together with cataract) in a

Table 1. Diabetic retinopathy (DR) diagnoses for 5340 patients photographed; 65.8 % (CI 64.6 to 67.1 %) had no DR; 4.1 % (CI 3.6 to 4.7 %) STDR

Diagnosis	Characteristics	*n*	%
No DR		3516	65.8
Non-proliferative DR not requiring further assessment	Dot or blot haemorrhages, with or without a few hard exudates outside 2 DD from centre of fovea	1543	28.9
Non-proliferative DR requiring further assessment	Cotton-wool spots in four quadrants and venous beading	61	1.1
Proliferative DR	New vessels	28	0.5
Macular involvement	Hard exudates in macula	192	3.6

further 0.4 %. In 23 patients (1.7 %) with indications of DR, photographic quality was so poor that we recommended immediate referral to ophthalmologists.

Further Diagnosis and Treatment

Examination by an ophthalmologist was recommended for 2.8 % of 5490 participants because photographs were not assessable and for a further 0.4 % due to conditions not related to diabetes (keratoconus 3, retinitis pigmentosa 3, retinal dystrophies 3, age-related macular degeneration 2, vitreous opacities 3, retinal detachment 2, intraocular hypertension 6).

No signs of DR were found in 64 % of all participants (corresponding to 65.8 % of patients whose photographs were assessable, Table 1). Renewed fundus photography in 2 years was offered to 54 %. Ten per cent were recommended further examination to be performed within 2 years by ophthalmologists because DR could be excluded but media opacities, perhaps indicating cataract surgery, or small pupils noticeably influenced the technical quality of photographs, and/or borderline elevation of intraocular pressure was recorded.

Photographic follow-up in 1 year was recommended for 24 % and ophthalmological examination after 1 year for 4 %. Seventy-five patients (1.4 %) were advised to have examination by an ophthalmologist within 6 months. Fluorescein angiography not resulting in subsequent photocoagulation was performed on 9 patients (0.2 %); photocoagulation (with or without previous angiography) was carried out on 188 (3.4 %). Pars plana vitrectomy was performed on 2 patients.

Discussion

Our results show that fundus photography by mobile teams in primary care is feasible and acceptable. Preliminary data suggest that it is also cost effective, with cost per examination 25 % less than that of a hospital-based one (detailed costings to be published elsewhere).

Doubling of eye examination uptake over previous systems was achieved by developing the service in close co-operation with patients and PHCC staff and modifying methods according to local needs. Co-operation of primary care staff was crucial and they took pride in their active role; an important contribution was their good relations with local opinion leaders and social networks, for example pharmacy staff, chiropodists, and hairdressers. Computer-based reminder lists were an important contributor to success.

Referral-based systems tend to be less successful in practice than is generally realized.[10] Only 36.5 % of the patients entering the present investigation claimed that their eyes had been examined within the past 2 years. Institution of a DR detection programme increased the proportion of patients adequately examined to 77.3 % in the first 16 PHCCs participating, increasing to 85 % in subsequent years. Attendance improved to 90–99 % where patients and staff were offered both more information and more influence on our activities.

In order to monitor the development and progression of DR, we have tried to achieve consistently good photographic quality. The number of photographs is twice that recommended in the London Protocol because a pilot study using two fields (unpublished) showed a 10 % failure rate due to media opacities, obtruding eyelashes, optical artefacts or difficulty in fixation.

Preventive maintenance efforts were rewarded with a low incidence of optical artifacts (further details available from the authors). In some elderly patients, stereoscopic assessment of fundus photographs made it easier to ascertain haemorrhages and distinguish hard exudates from retinal pigment epithelium defects or artifacts.

Using a 3.7 m wide screen, two or three images can be projected side by side, giving opportunities for fast and effective teaching and learning. It is easy to evaluate progression of DR when current and previous images can be compared. The methodology for photography and grading may be compared to that used in the EURODIAB study and validated against seven-field stereo photography systematically graded by independent experts in Wisconsin.[17,19] High-quality fundus photography is much better for the detection of early signs of DR than examination by a retinal specialist.[21] A 10 % random sample of our first 5000 patients' photographs has now been re-graded at the Retinopathy Grading Centre, London (validation data to be published). Results from another re-grading performed there, based on a St Vincent field guide-book,[20] recently appeared from the

Welsh Community Diabetic Retinopathy Study, showing 10 % STDR prevalence and supporting a combination of decentralized photography and centralized grading.[22] Since ETDRS slides[18] concentrate on advanced STDR rarely seen in primary care, further investigation might support the introduction of additional slides showing incipient DR. The Hammersmith EURODIAB standard slides have been useful in our work and deserve widespread use.

The mobile fundus photography programme was built on the expressed needs and on the express invitation of doctors and nurses working in primary care. It was designed to support and inform the care provided by them rather than emulate previous 'top down' programmes which met with limited success.[11,23] Immediate feedback of patients' results to PHCCs is appreciated by GPs as it allows them to consider early intensification of treatment and provides a concrete basis for discussing such options with patients.

It has been claimed that everyday care is little affected by issuing guidelines,[24] even when these are written by GPs and reflect the realities of primary care.[25] Nevertheless, an eye care consensus statement[26] and the Swedish national guidelines for diabetes care, published in November 1996, were recently utilized by GPs during negotiations with administrators.

There are several barriers to prevention of vision loss in diabetes.[27] Some are amenable to action by GPs. In particular, factors affecting patient uptake of eye examination services need to be addressed.[8] Costs and effort, for instance travel, may deter patients from attending, as will fears of blindness.[27] Examining patients in the more familiar and reassuring environment of their own PHCC should minimize such problems. People with diabetes have told us they preferred getting information on examination results through a continuing dialogue with their own GP or diabetes nurse.

Early diagnosis of STDR using high-quality fundus photography is cost-saving to the Government[28] and highly cost-effective from the perspective of the taxpayer or insurance provider; the cost per quality-adjusted life-year saved is very competitive.[29] Health authorities should be told that techniques for the successful detection and treatment of STDR are available[30] and their community-wide implementation is justified on the strength of the available evidence.[31]

It is important to keep in mind that there is still a lack of awareness of the importance of regular eye examinations and timely photocoagulation for diabetes patients[32] and that some ophthalmologists may delay laser treatment beyond the time window when treatment effect is optimal.[33] People with diabetes need to know that examinations ought not to be deferred until vision deteriorates.[7] To avoid STDR due to cataract surgery, diabetes patients need retinal assessment before and after lens implantation.[12] At the inception of the programme, some doctors stated that they had been reluctant to mention eye complications to patients. More optimistic views of prognosis may now be gained from attending training courses or by reading one of several excellent reviews.[34,35] Having discussed photography results, several patients and their doctors reported a sense of relief and an intent to achieve near-normoglycaemia.

Many doctors have feared worsening DR in their patients because of improved metabolic control.[36] Signs of ischaemia occurring for this reason are usually short-lived.[37] Fears may be allayed if regular eye examinations are available; otherwise there may be unjustified reluctance to commence (or intensify) insulin treatment. Close follow-up of these patients is essential. When HbA_{1c} is slowly reduced by less than two percentage units over 10–12 months, the risk of DR progression is minimal.[38,39]

After more than 10 years of pioneering work, most of it done in the UK, the value of retinal photography for diabetes management in primary care is well established. The importance of early DR diagnosis and timely treatment is now clearly documented, as is the importance of high coverage rates and systems to ensure follow-up.

In conclusion, the provision of community-based fundus photography by mobile teams working in partnership with GPs is a promising model for the prevention of avoidable blindness in diabetes.

Acknowledgements

The authors are grateful to all who helped. X.-H. Yu, I. Bartha, K. Jägsander, M. Skoglund, A. Britz, M. Bredelius, M. Heiniola and L. Williams examined patients, graded photographs, entered and checked data. M. Gustafsson typed letters and handled many contacts. H. Ericsson, H. Jansson and U.-G. Neglén helped with computer programming. The manuscript was read and commented on by S. Aldington. Participating people with diabetes, their social network, primary care and ophthalmology staff and many others are owed our gratitude for friendly co-operation over the years.

References

1. World Health Organization (WHO)/IDF Europe. Diabetes care and research in Europe: the Saint Vincent Declaration. *Diabetic Med* 1990; **7**: 360.
2. Retinopathy Working Party (Kohner EM, Porta M). A protocol for screening for diabetic retinopathy in Europe. *Diabetic Med* 1991; **8**: 263–267.
3. Witkin SR, Klein R. Ophthalmologic care for persons with diabetes. *J Am Med Assoc* 1984; **251**: 2534–2537.
4. Klein R, Klein BE, Moss SE, Davis MD, DeMets DL. The Wisconsin Epidemiologic Study of Diabetic Retinopathy. VI: retinal photocoagulation. *Ophthalmology* 1987; **94**: 747–753.
5. Brechner RJ, Cowie CC, Howie LJ, Herman WH, Will JC, Harris MI. Ophthalmic examination among adults with diagnosed diabetes mellitus. *J Am Med Assoc* 1993; **270**: 1714–1718.
6. Harris M. Medical care of patients with diabetes: epidemiologic aspects. *Ann Intern Med* 1996; **24**: 117–122.

7. Klein R, Klein BEK, Moss SE, DeMets DL. The validity of a survey question to study diabetic retinopathy. *Am J Epidemiol* 1986; **124**: 104–110.
8. Bachmann MO, Nelson SJ. Impact of diabetic retinopathy screening on a British district population: case detection and blindness prevention in an evidence-based model. *J Epidemiol Community Health* 1998; **52**: 45–52.
9. Bäcklund LB, Algvere PV, Rosenqvist U. New blindness in diabetes reduced by more than one-third in Stockholm County. *Diabetic Med* 1997; **14**: 732–740.
10. Dickson PF, McCarty CA, Keeffe JE, Baxter R, Harper CA, Taylor HR. Diabetic retinopathy: examination practices and referral patterns of general practitioners. *Med J Aust* 1996; **164**: 341–344.
11. Carlson A, Rosenqvist U. Diabetes care organization, process, and patient outcomes: effects of a diabetes control program. *Diabetes Educ* 1991; **17**: 42–48.
12. Olk RJ, Lee CM. *Diabetic Retinopathy. Practical Management.* New York: J B Lippincott, 1993.
13. Wilson JMG, Jungner G. *Principles and Practice of Screening for Disease*. World Health Organization Public Health Papers No. 34. Geneva, Switzerland: WHO, 1968: 26–27.
14. Wald N, Cuckle H. Reporting the assessment of screening and diagnostic tests. *Br J Obstet Gynaecol* 1989; **96**: 389–396.
15. Anonymous. Cancer of the cervix: death by incompetence (Editorial). *Lancet* 1985; **2**: 363–364.
16. World Health Organization Expert Committee. *Diabetes Mellitus.* Technical Report Series No. 742. Geneva, Switzerland: WHO, 1985.
17. Kuiv R, Tein P, Algvere PV, Bäcklund LB, Holm O. Photographic detection of retinopathy in insulin-treated diabetes. A population study in the city of Tartu, Estonia. *Acta Ophthalmol Scand* 1997; **75**: 447–456.
18. Aldington SJ, Kohner EM, Meuer S, Klein R, Sjølie AK. Methodology for retinal photography and assessment of diabetic retinopathy: the EURODIAB IDDM Complications Study. *Diabetologia* 1995; **38**: 437–444.
19. Early Treatment Diabetic Retinopathy Study Research Group. Grading diabetic retinopathy from stereoscopic color fundus photographs – an extension of the modified Airlie House classification. ETDRS Report Number 10. *Ophthalmology* 1991; **98**: 786–806.
20. Kohner EM, Porta M. *Screening for Diabetic Retinopathy: A Field Guide-Book*. Pisa, Italy: Pacini Editore, 1992.
21. Kinyoun JL, Martin DC, Fujimoto WY, Leonetti DL. Ophthalmoscopy versus fundus photography for detecting and grading diabetic retinopathy. *Invest Ophthalmol Vis Sci* 1992; **33**: 1888–1893.
22. Gibbins RL, Owens DR, Allen JC, Eastman L. Practical application of the European Field Guide in screening for diabetic retinopathy by using ophthalmoscopy and 35 mm retinal slides. *Diabetologia* 1998; **41**: 59–64.
23. Rosenqvist U. Diabetes care management training and the need for a patient perspective: a 10-year evolution of training strategies and goals. *Patient Educ Couns* 1995; **26**: 209–213.
24. Kraft SK, Marrero DG, Lazaridis EN, Fineberg N, Qiu C, Clark CM Jr. Primary care physicians' practice patterns and diabetic retinopathy. Current levels of care. *Arch Fam Med* 1997; **6**: 29–37, 38–41.
25. Hetlevik I, Holmen J, Midthjell K. Treatment of diabetes mellitus – physicians' adherence to clinical guidelines in Norway. *Scand J Prim Health Care* 1997; **15**: 193–197.
26. Konsensusuttalande. *Synhotande näthinneförändringar vid diabetes* (Consensus statement. *Sight-threatening Retinal Disease in Diabetes*) [In Swedish]. Spri Publ. No. 216. Stockholm, Sweden: Medical Research Council and National Health Research and Development Institute, 1992.
27. Klein R. Barriers to prevention of vision loss caused by diabetic retinopathy. *Arch Ophthalmol* 1997; **115**: 1073–1075.
28. Javitt JC, Aiello LP, Chiang Y, Ferris FL 3rd, Canner JK, Greenfield S. Preventive eye care in people with diabetes is cost-saving to the federal government. Implications for health-care reform. *Diabetes Care* 1994; **17**: 909–917.
29. Javitt JC, Aiello LP. Cost-effectiveness of detecting and treating diabetic retinopathy. *Ann Intern Med* 1996; **124**: 164–169.
30. Vijan S, Stevens DL, Herman WH, Funnell MM, Standiford CJ. Screening, prevention, counseling, and treatment for the complications of type II diabetes mellitus. Putting evidence into practice. *J Gen Intern Med* 1997; **12**: 567–580.
31. Bachmann MO, Nelson SJ. *Screening for Diabetic Retinopathy*. A quantitative overview of the evidence, applied to the populations of health authorities and boards. Health Care Evaluation Unit, Department of Social Medicine, University of Bristol, 1996.
32. Pasagian-Macaulay A, Basch CE, Zybert P, Wylie-Rosett J. Ophthalmic knowledge and beliefs among women with diabetes. *Diabetes Educ* 1997; **23**: 433–437.
33. Agardh E, Agardh C-D, Hansson-Lundblad C, Cavallin-Sjöberg U. The importance of early diagnosis of treatable diabetic retinopathy for the four-year visual outcome in older-onset diabetes mellitus. *Acta Ophthalmol Scand* 1996; **74**: 166–170.
34. Kohner EM. Diabetic retinopathy. *Br Med J* 1993; **307**: 1195–1199.
35. Klein R, Klein BE. Diabetic eye disease. *Lancet* 1997; **350**: 197–204.
36. Chantelau E, Kohner EM. Why some cases of retinopathy worsen when diabetic control improves. *Br Med J* 1997; **315**: 1105–1106.
37. Wang PH, Lau J, Chalmers TC. Meta-analysis of effects of intensive blood glucose control on late complications of type I diabetes. *Lancet* 1993; **341**: 1306–1309.
38. Funatsu H, Yamashita O, Ohashi Y, Ishigaki T. Effect of rapid glycemic control on progression of diabetic retinopathy. *Jpn J Ophthalmol* 1992; **36**: 356–367.
39. Reichard P, Nilsson B-Y, Rosenqvist U. The effect of long-term intensified insulin treatment on the development of microvascular complications of diabetes mellitus. *N Engl J Med* 1993; **329**: 304–309.

